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Wong

(10) **Patent No.: US 9,146,957 B2**
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(54) **METHOD AND SYSTEM FOR GENERATING OPTIMAL MEMBERSHIP-CHECK QUERIES**

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(73) Assignee: **Business Objects Software Ltd.**, Dublin (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 371 days.

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G06F 17/30 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 17/30466*** (2013.01); ***G06F 17/30436*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 17/30466; G06F 17/30436
See application file for complete search history.

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Primary Examiner — Tarek Chbouki
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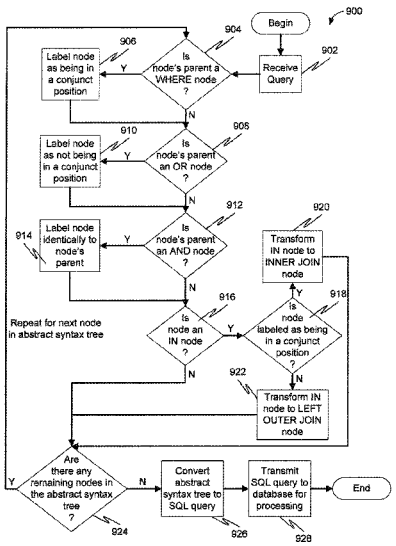
(57) **ABSTRACT**

A method and system of transforming a query at a web server are provided. An abstract syntax tree representing the query can be traversed from the top down, for each node in the abstract syntax tree: labeling the node as being in a conjunct position when the node's parent is a WHERE node; labeling the node as being not in a conjunct position when the node's parent is an OR node; and labeling the node identically to the node's parent node when the node's parent is an AND node. Then any IN node in the abstract syntax tree can be transformed to an INNER JOIN node when the IN node is labeled as being in a conjunct position. The abstract syntax tree can be converted into a Structured Query Language (SQL) query, which can then be passed to a database for processing.

13 Claims, 19 Drawing Sheets



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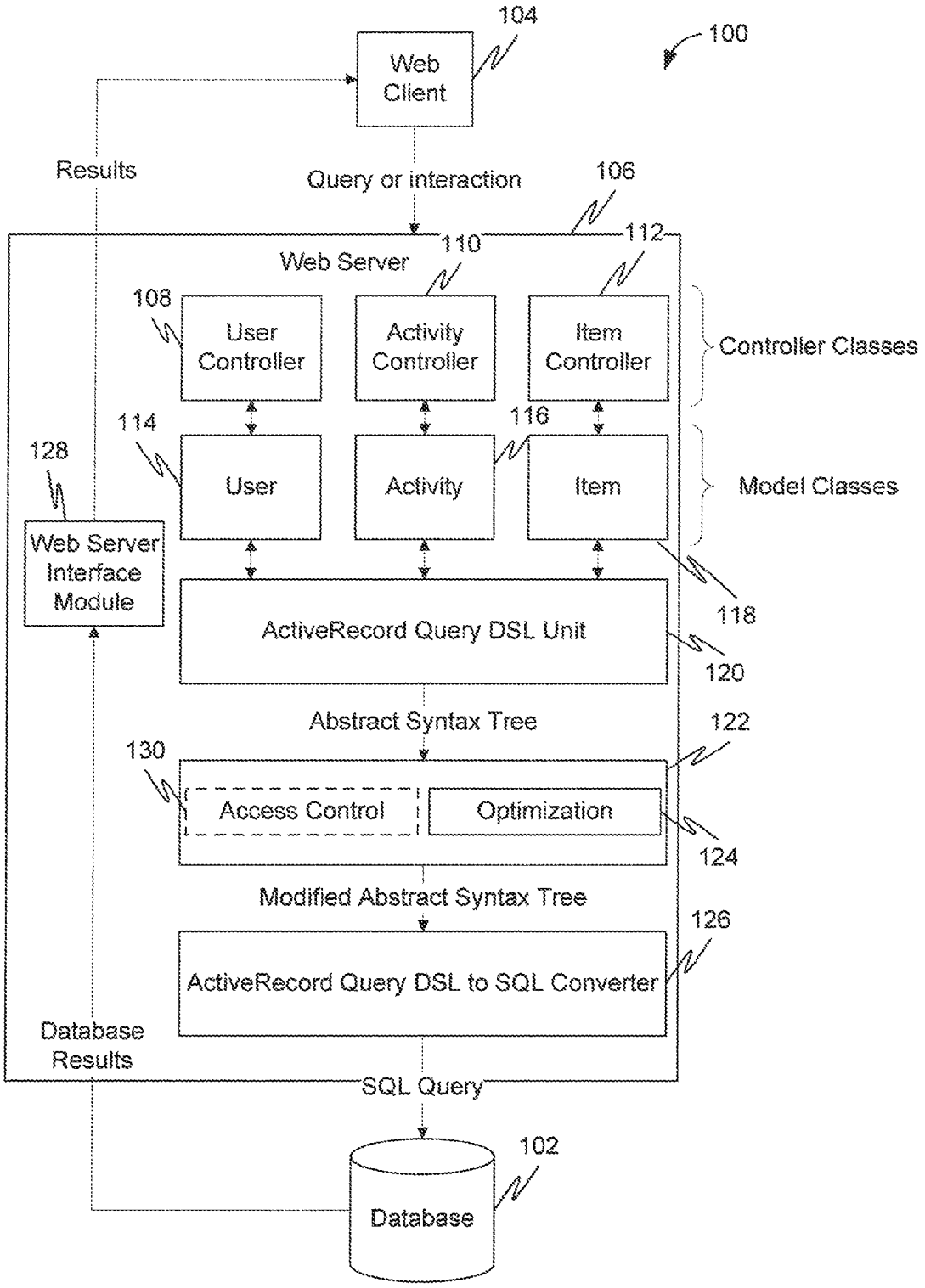
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100
Web Client
Results
Query or interaction
106
110
112
Web Server
108
User Controller
Activity Controller
Item Controller
Controller Classes
114
116
128
User
Activity
Item
Model Classes
Web Server Interface Module
ActiveRecord Query DSL Unit
118
120
Abstract Syntax Tree
122
130
Access Control
Optimization
124
Modified Abstract Syntax Tree
126
ActiveRecord Query DSL to SQL Converter
Database Results
SQL Query
102
Database

FIG. 1

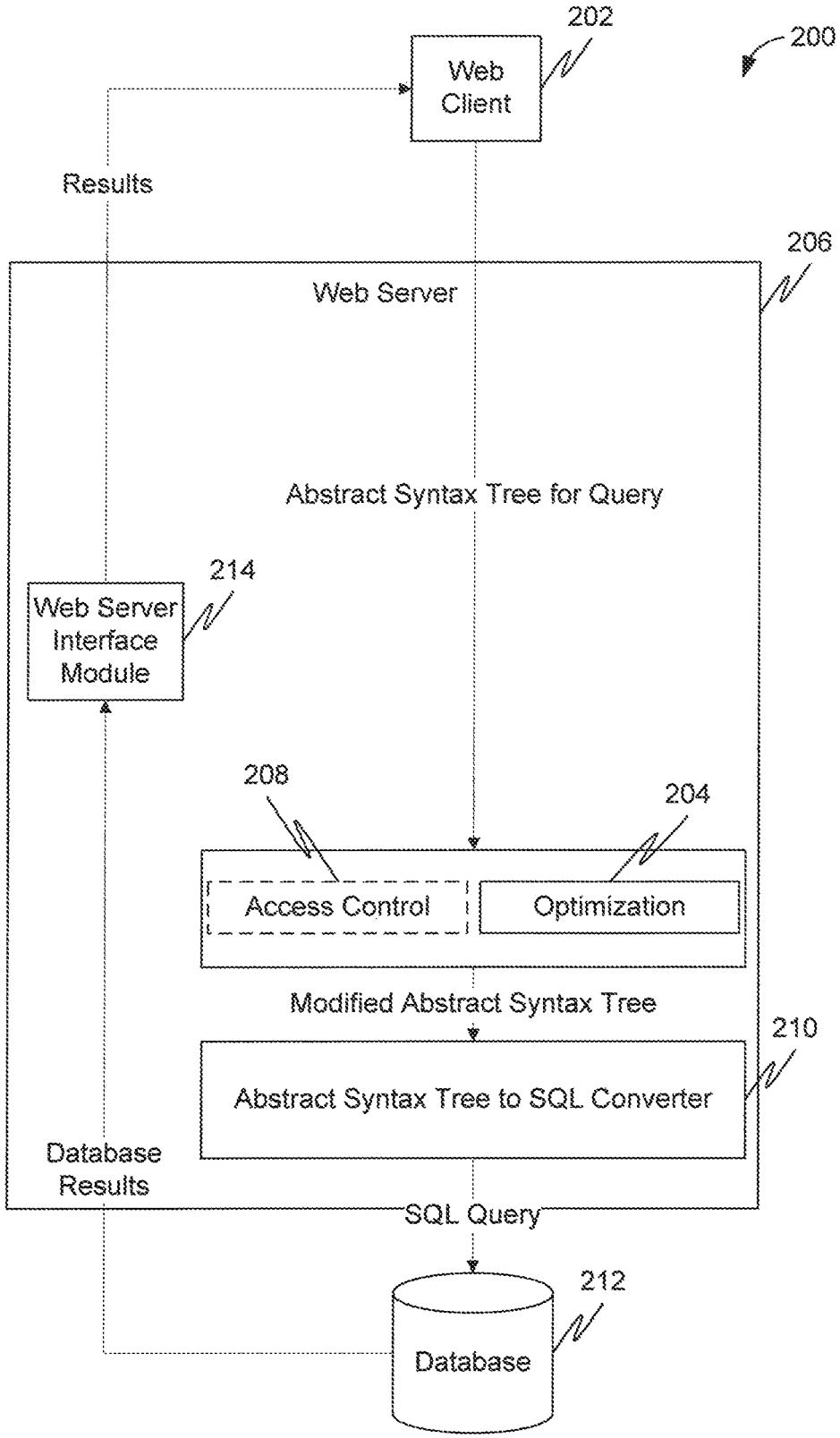

202
200
Web Client
Results
206
Web Server
Abstract Syntax Tree for Query
214
Web Server Interface Module
208
204
Access Control
Optimization
Modified Abstract Syntax Tree
210
Abstract Syntax Tree to SQL Converter
Database Results
SQL Query
212
Database

FIG. 2

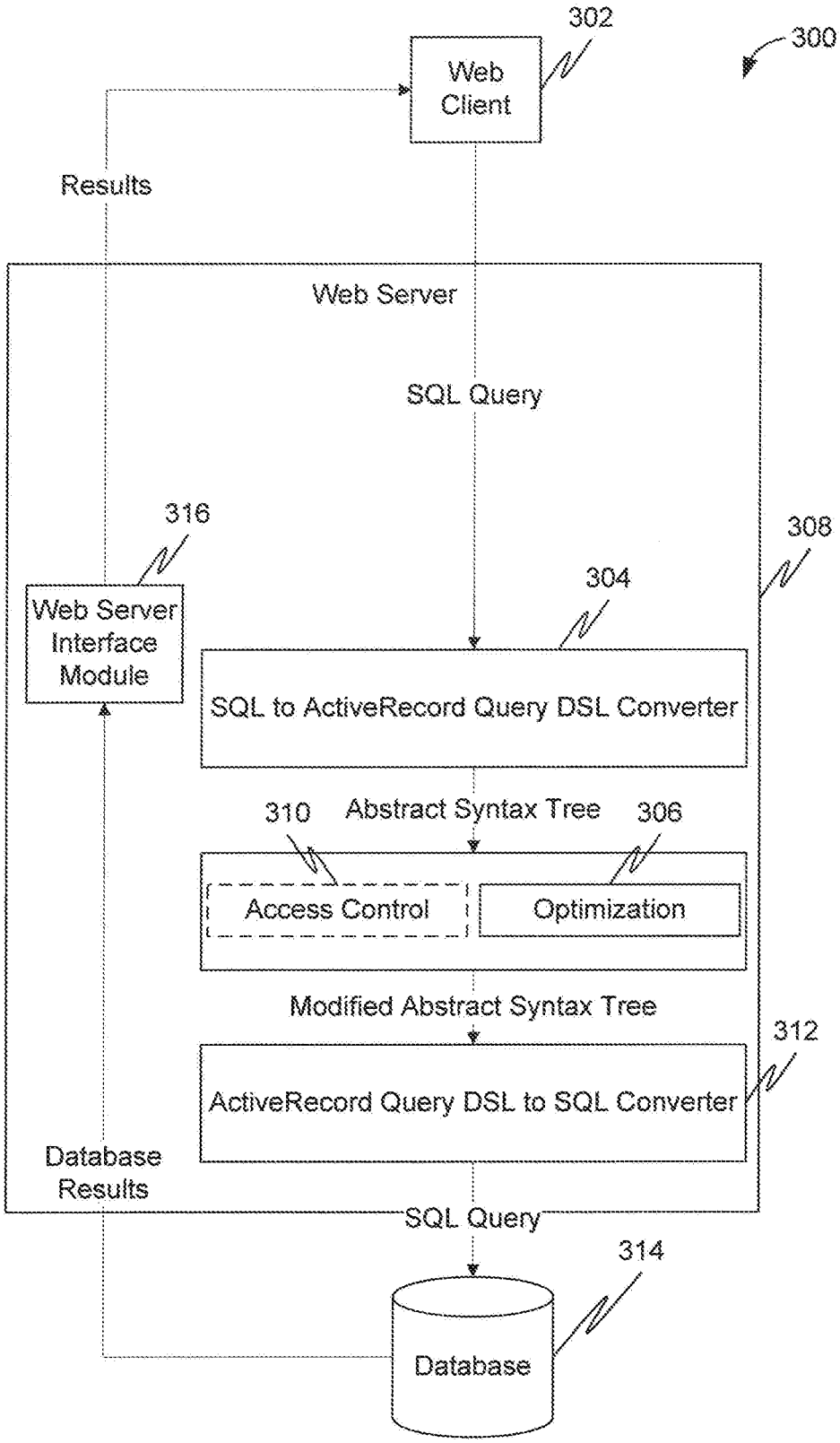
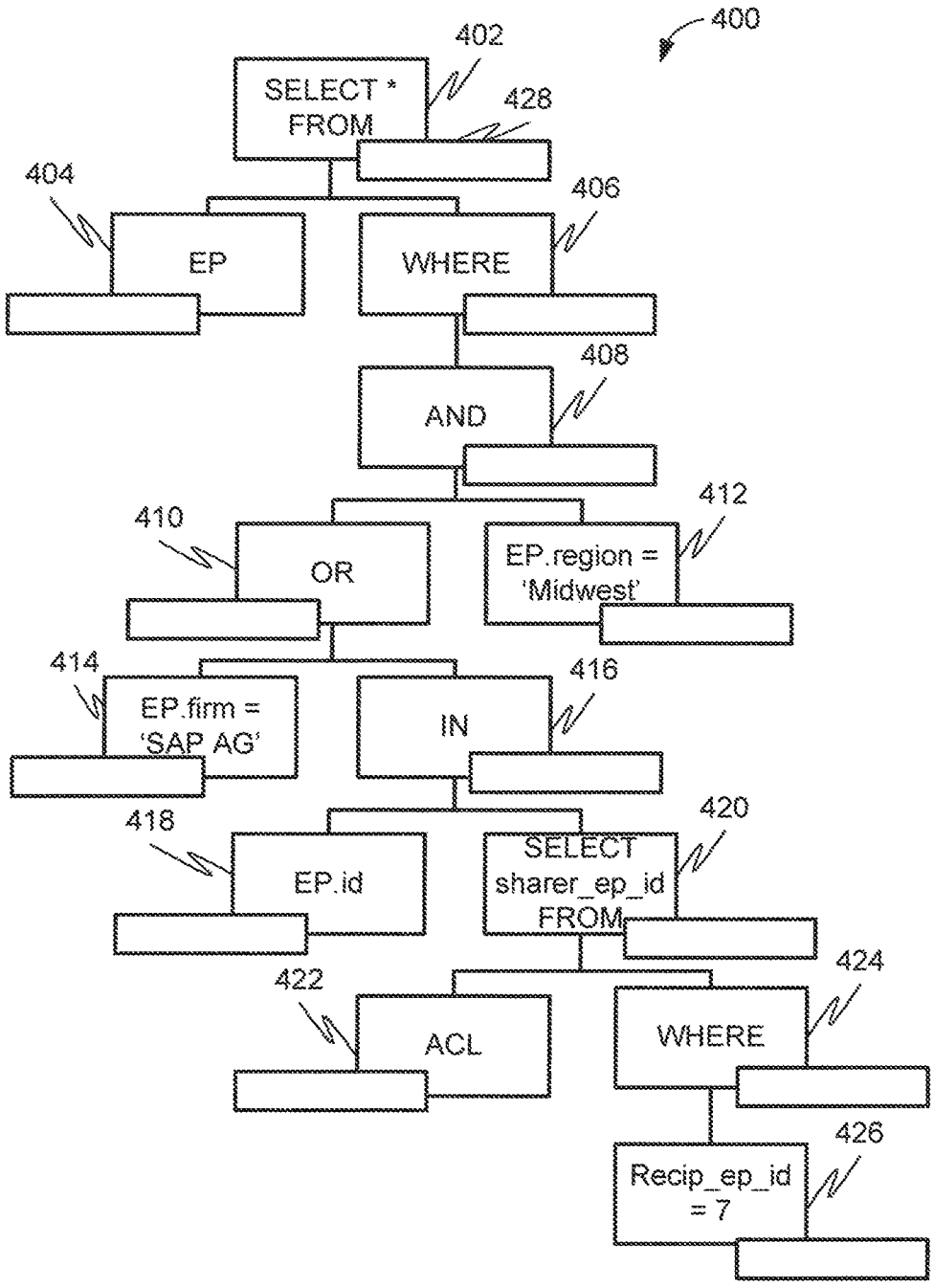

302
300
Web Client
Results
Web Server
SQL Query
316
308
304
Web Server Interface Module
SQL to ActiveRecord Query DSL Converter
310
Abstract Syntax Tree
306
Access Control
Optimization
Modified Abstract Syntax Tree
312
ActiveRecord Query DSL to SQL Converter
Database Results
SQL Query
314
Database

FIG. 3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402
SELECT *
FROM
428
404
406
EP
WHERE
408
AND
410
412
OR
EP.region =
'Midwest'
414
416
EP.firm =
'SAP AG'
IN
418
420
EP.id
SELECT
sharer_ep_id
FROM
422
424
ACL
WHERE
426
Recip_ep_id
= 7

FIG. 4A

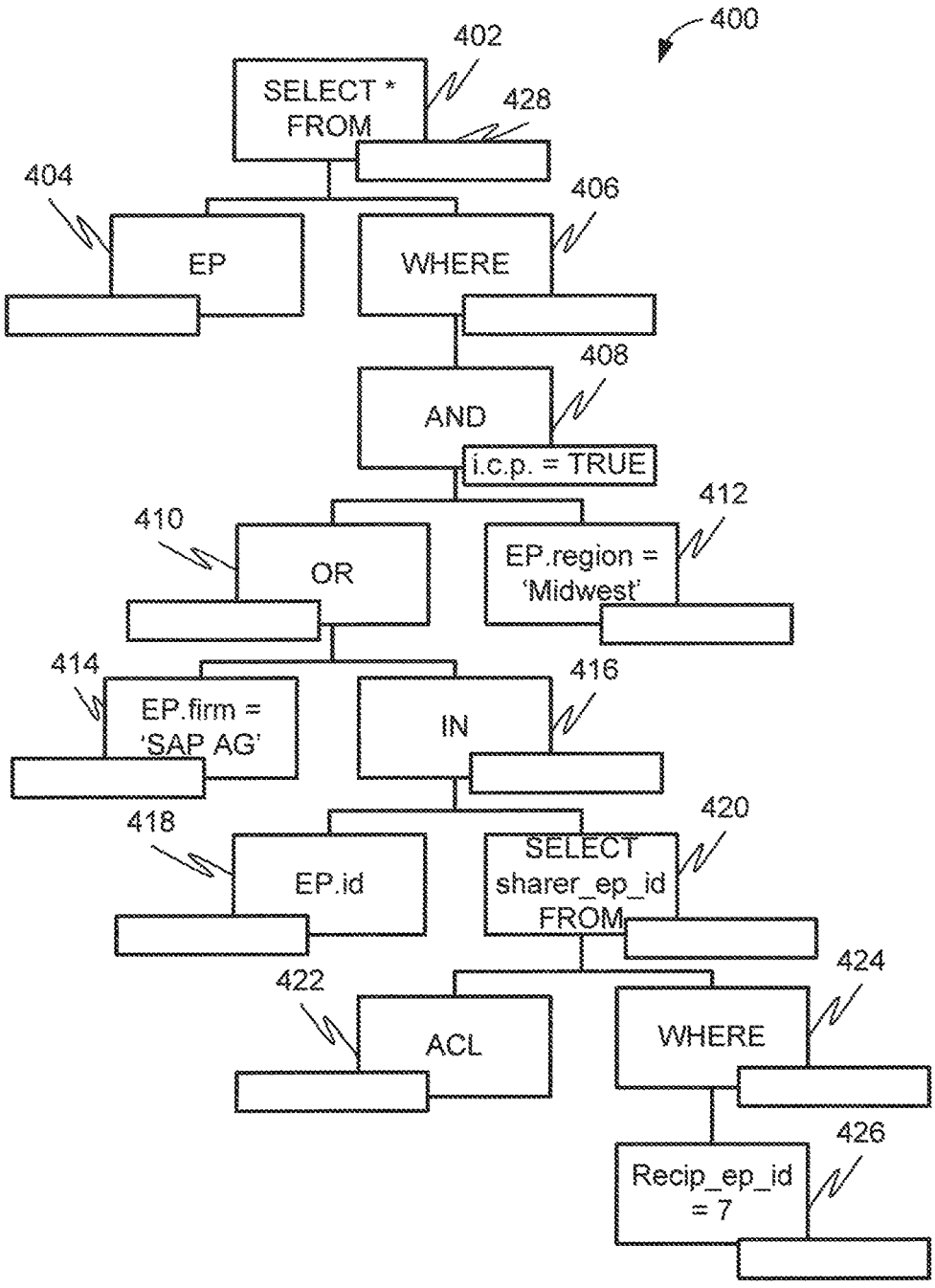
400
402
SELECT *
FROM
428
404
406
EP
WHERE
408
AND
i.c.p. = TRUE
410
412
OR
EP.region =
'Midwest'
414
416
EP.firm =
'SAP AG'
IN
418
420
EP.id
SELECT
sharer_ep_id
FROM
422
424
ACL
WHERE
426
Recip_ep_id
= 7

FIG. 4B

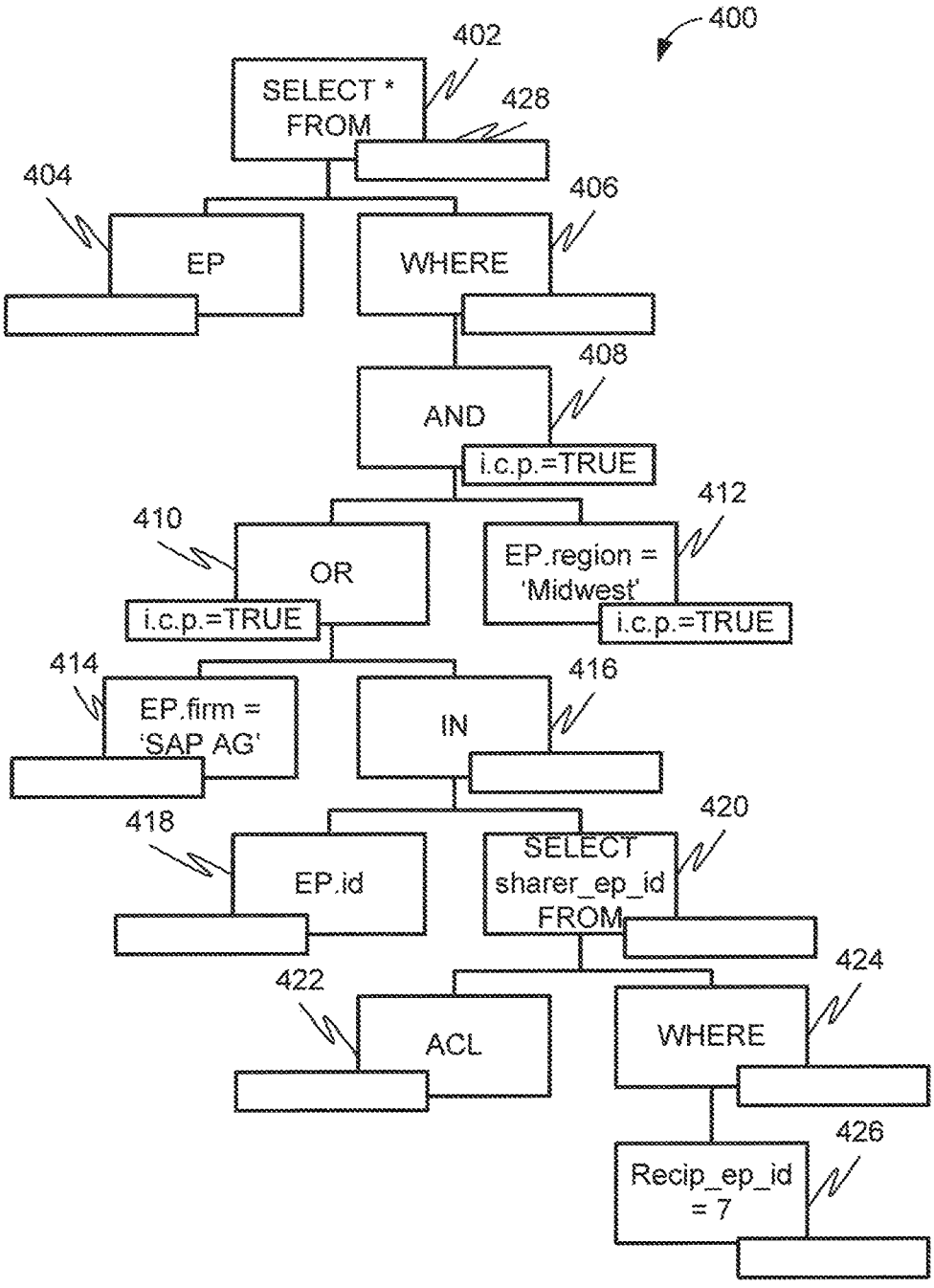
400
402
SELECT *
FROM
428
404
406
EP
WHERE
408
AND
i.c.p.=TRUE
410
412
OR
EP.region =
'Midwest'
i.c.p.=TRUE
i.c.p.=TRUE
414
416
EP.firm =
'SAP AG'
IN
418
420
EP.id
SELECT
sharer_ep_id
FROM
422
424
ACL
WHERE
426
Recip_ep_id
= 7

FIG. 4C

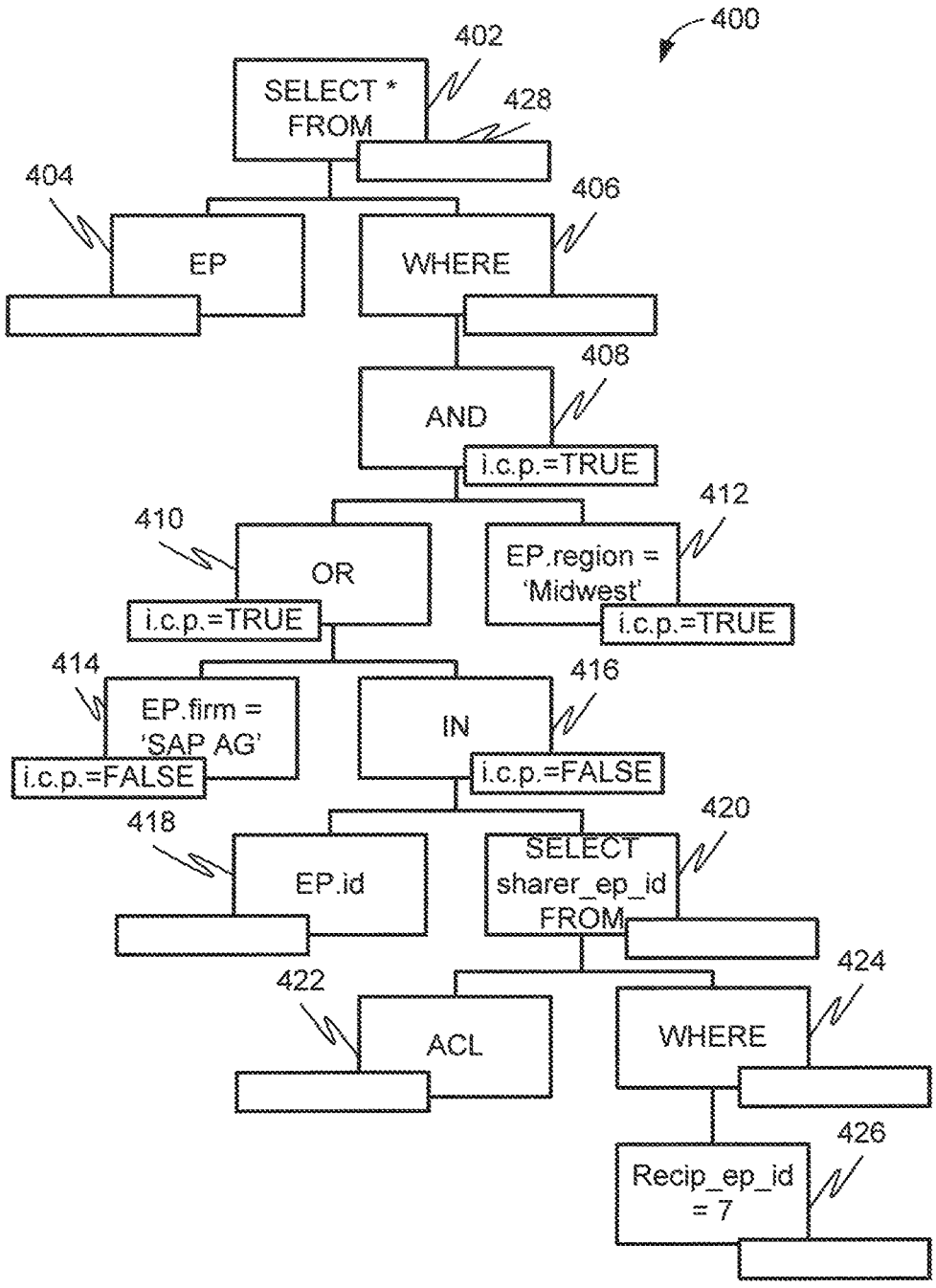
400
402
SELECT *
FROM
428
404
406
EP
WHERE
408
AND
i.c.p.=TRUE
410
412
OR
EP.region =
'Midwest'
i.c.p.=TRUE
i.c.p.=TRUE
414
416
EP.firm =
'SAP AG'
IN
i.c.p.=FALSE
i.c.p.=FALSE
418
420
EP.id
SELECT
sharer_ep_id
FROM
422
424
ACL
WHERE
426
Recip_ep_id
= 7

FIG. 4D

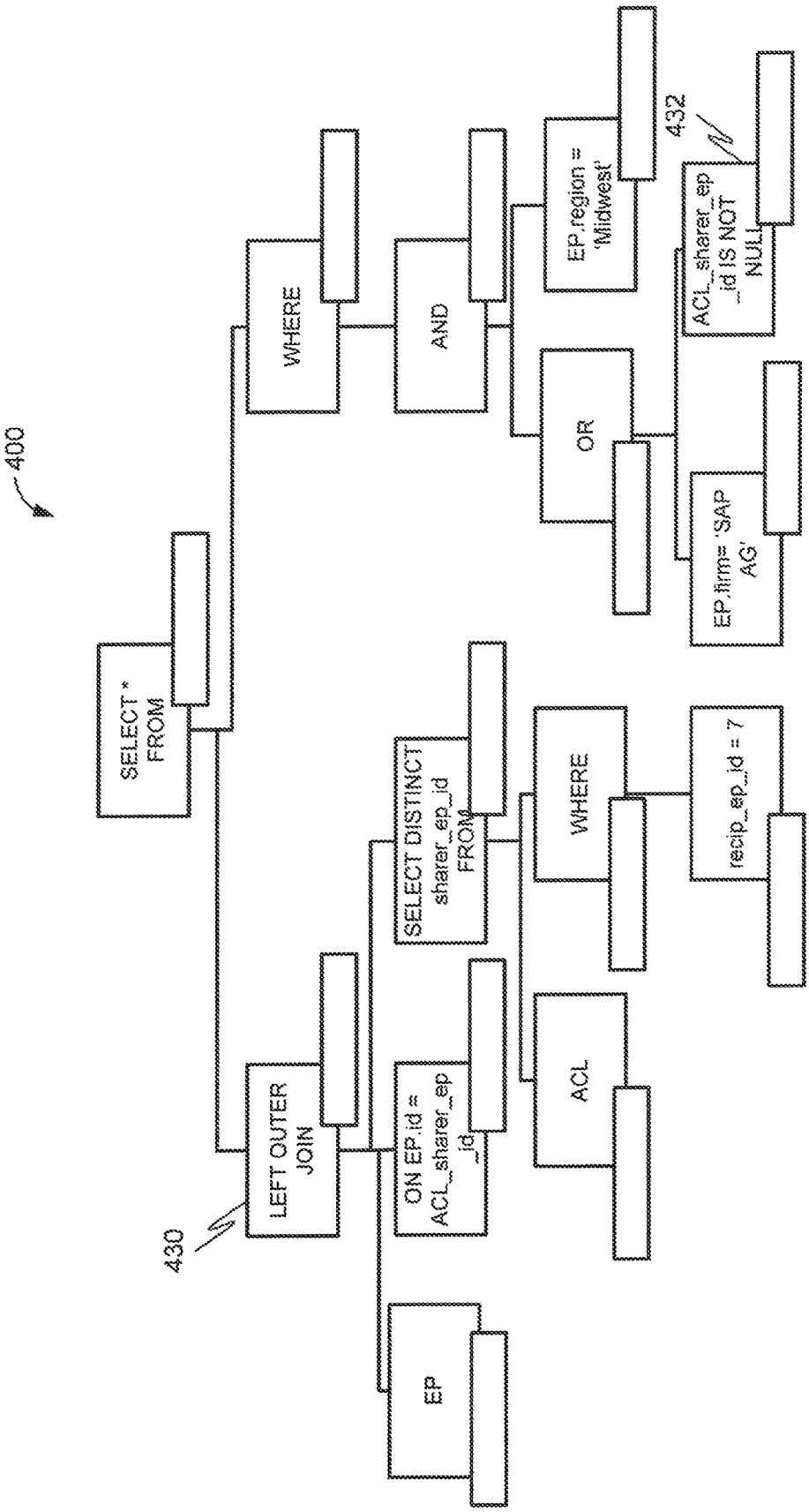
400
SELECT * FROM
WHERE
AND
EP.region = 'Midwest'
OR
ACL_sharer_ep _id IS NOT NULL
EP.firm= 'SAP AG'
432
LEFT OUTER JOIN
ON EP.id = ACL_sharer_ep _id
SELECT DISTINCT sharer_ep_id FROM
WHERE
recip_ep_id = 7
ACL
EP
430

FIG. 4E

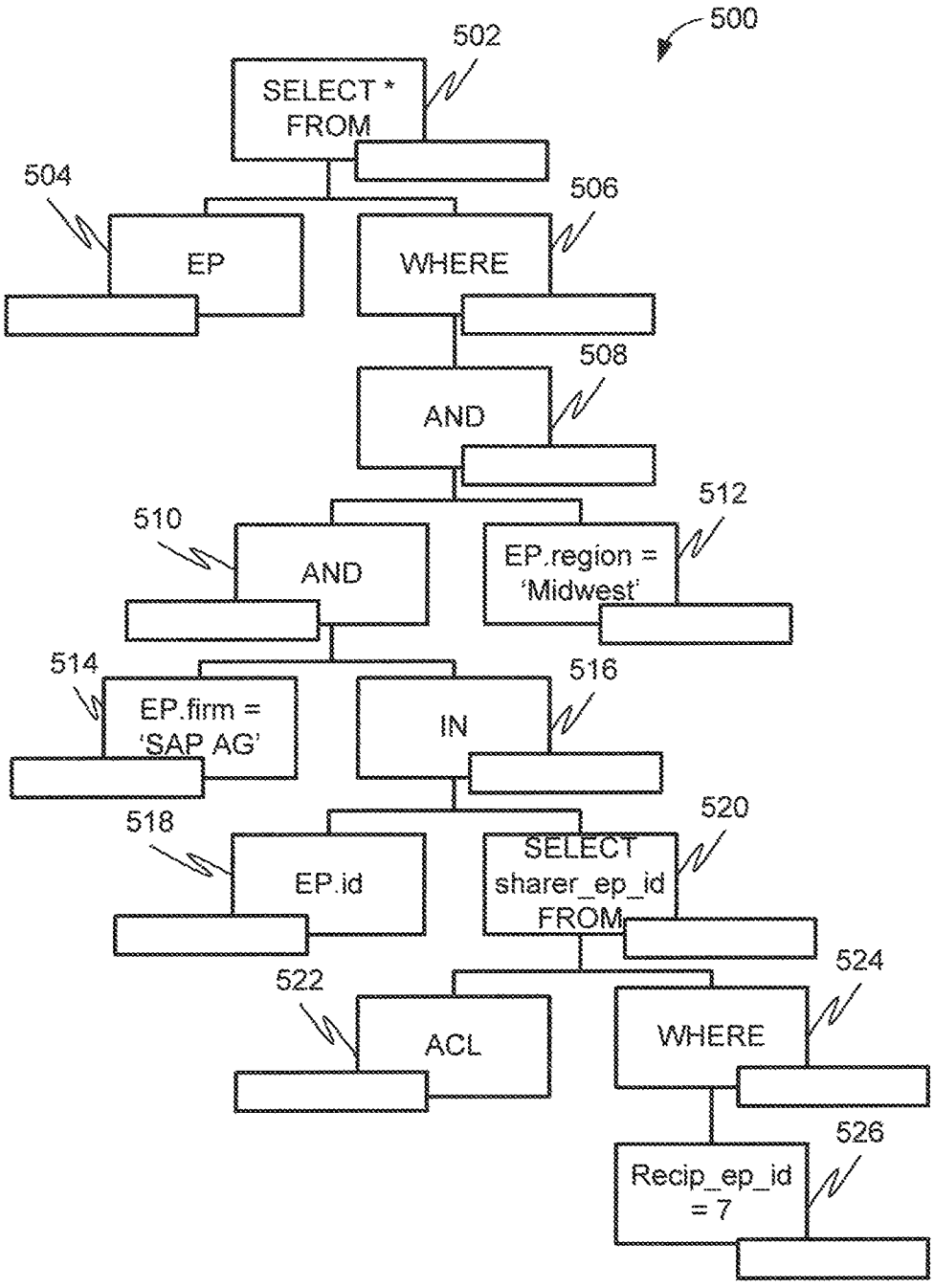
500
502
SELECT * FROM
504
EP
506
WHERE
508
AND
510
AND
512
EP.region = 'Midwest'
514
EP.firm = 'SAP AG'
516
IN
518
EP.id
520
SELECT sharer_ep_id FROM
522
ACL
524
WHERE
526
Recip_ep_id = 7

FIG. 5A

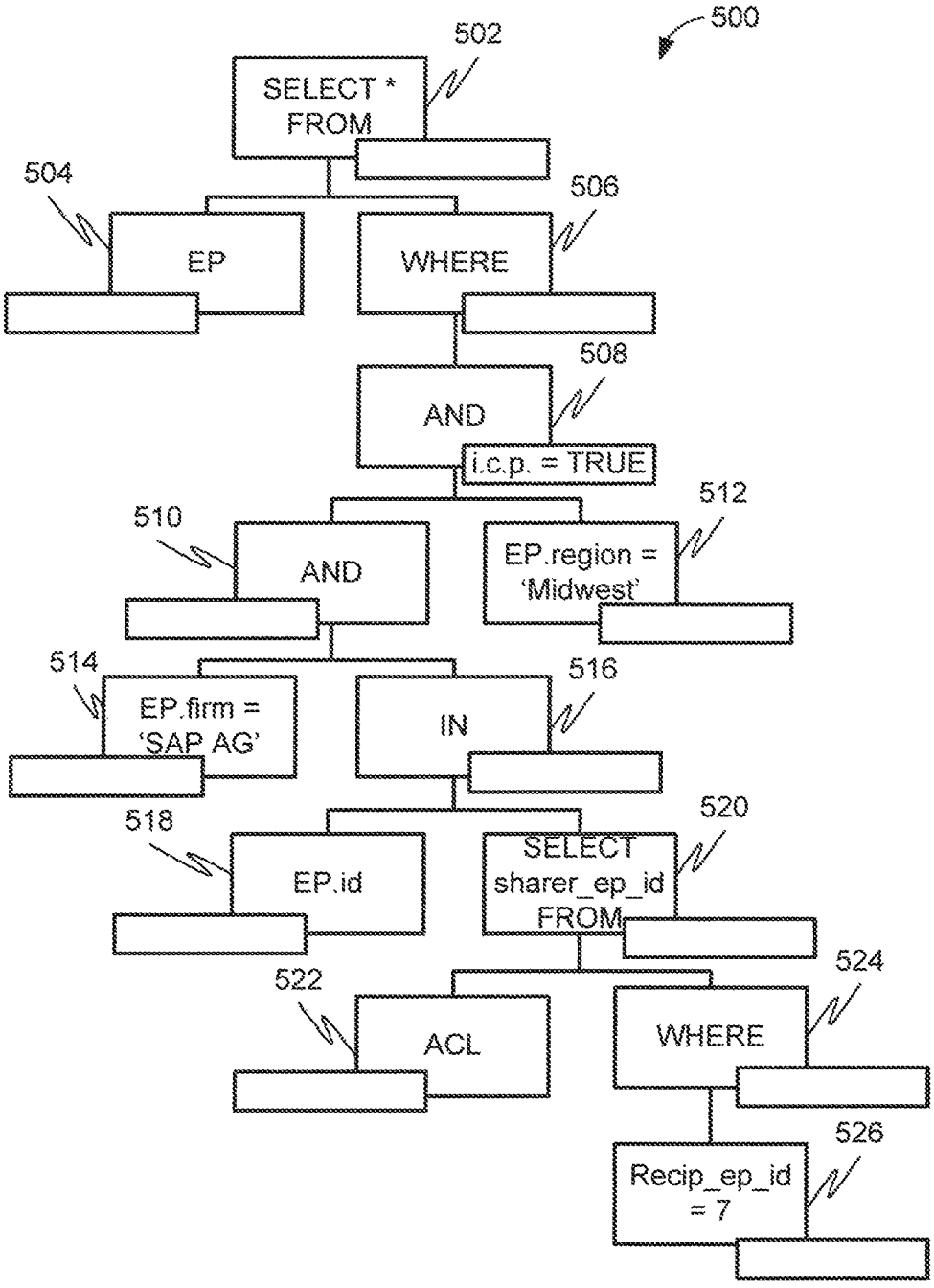
500
502
SELECT * FROM
504
EP
506
WHERE
508
AND
i.c.p. = TRUE
510
AND
512
EP.region = 'Midwest'
514
EP.firm = 'SAP AG'
516
IN
518
EP.id
520
SELECT sharer_ep_id FROM
522
ACL
524
WHERE
526
Recip_ep_id = 7

FIG.5B

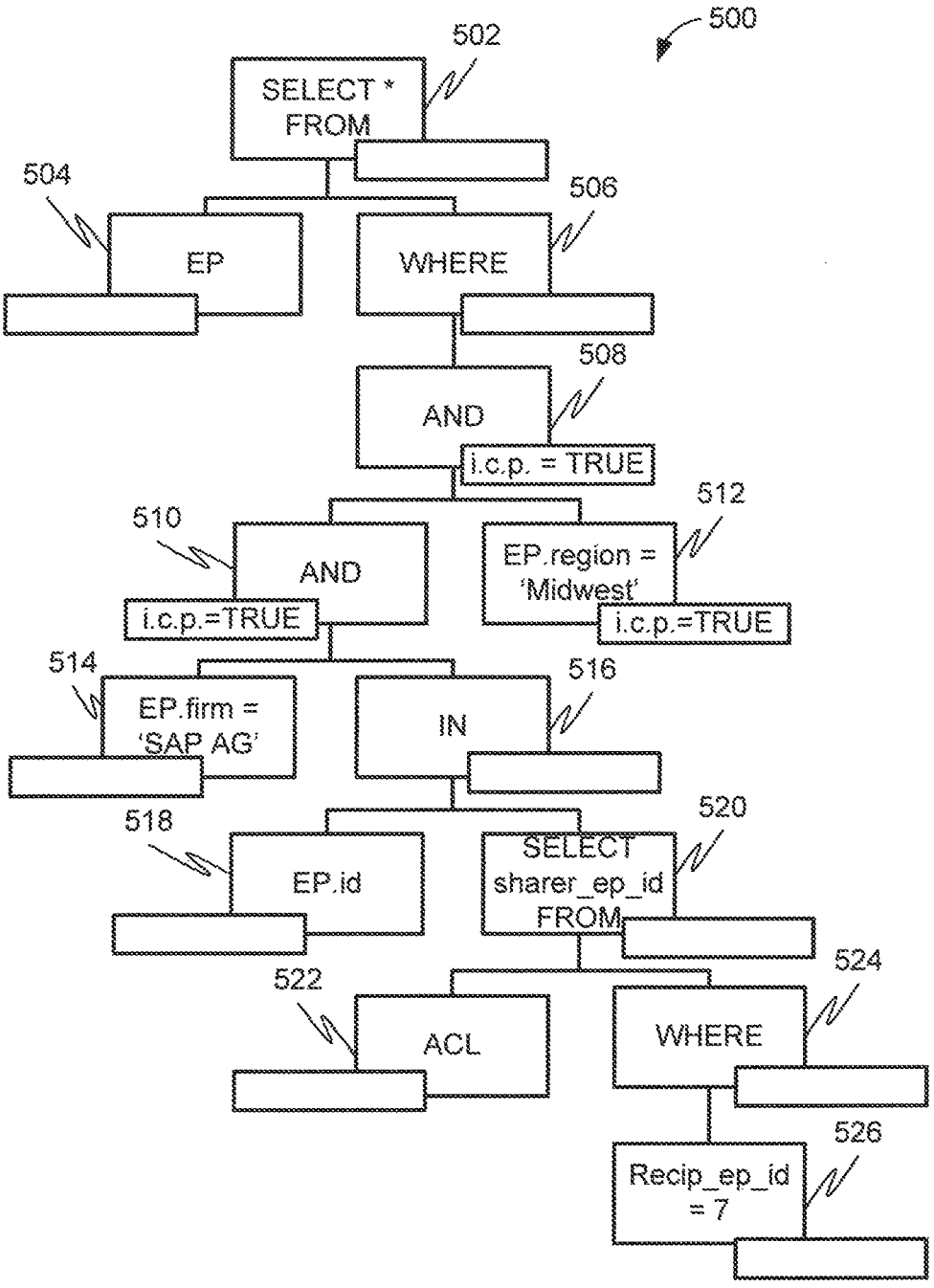
500
502
SELECT *
FROM
504
EP
506
WHERE
508
AND
i.c.p. = TRUE
510
AND
i.c.p.=TRUE
512
EP.region =
'Midwest'
i.c.p.=TRUE
514
EP.firm =
'SAP AG'
516
IN
518
EP.id
520
SELECT
sharer_ep_id
FROM
522
ACL
524
WHERE
526
Recip_ep_id
= 7

FIG.5C

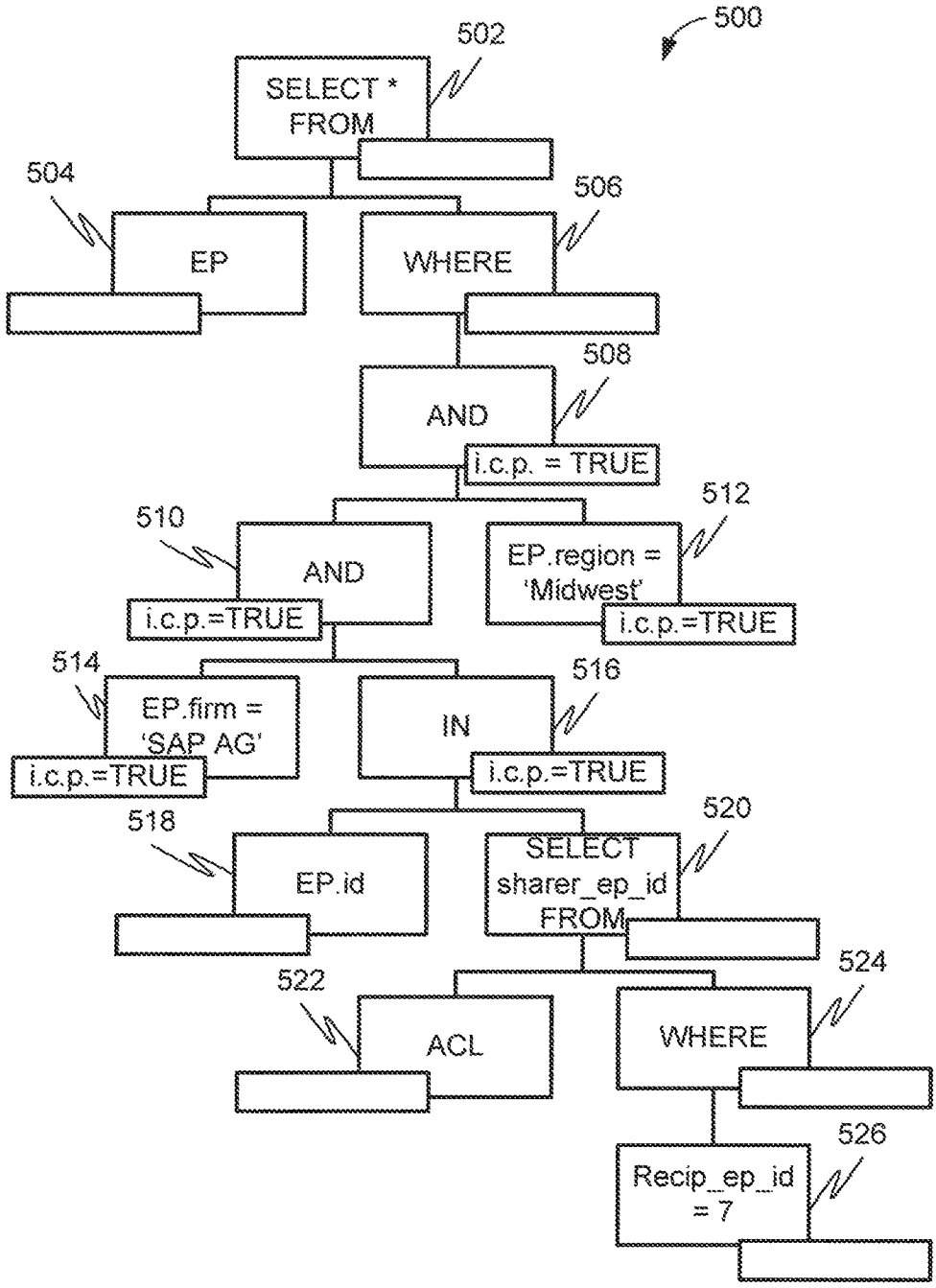
500
502
SELECT * FROM
504
EP
506
WHERE
508
AND
i.c.p. = TRUE
510
AND
i.c.p.=TRUE
512
EP.region = 'Midwest'
i.c.p.=TRUE
514
EP.firm = 'SAP AG'
i.c.p.=TRUE
516
IN
i.c.p.=TRUE
518
EP.id
520
SELECT sharer_ep_id FROM
522
ACL
524
WHERE
526
Recip_ep_id = 7

FIG.5D

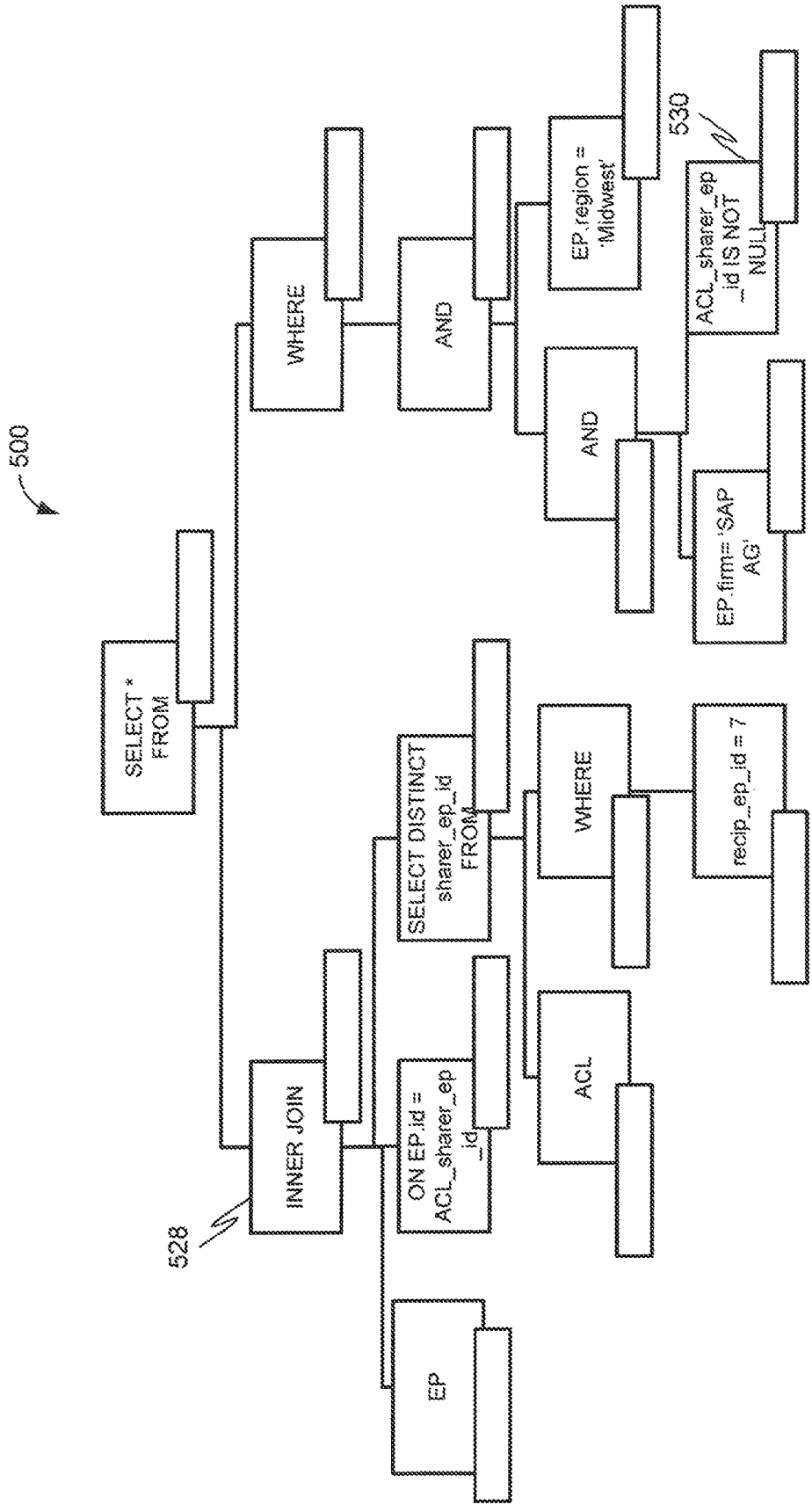
500
SELECT * FROM
WHERE
AND
EP.region = 'Midwest'
530
ACL_sharer_ep_id IS NOT NULL
AND
EP.firm= 'SAP AG'
SELECT DISTINCT sharer_ep_id FROM
WHERE
recip_ep_id = 7
528
INNER JOIN
ON EP.id = ACL_sharer_ep_id
ACL
EP

FIG. 5E

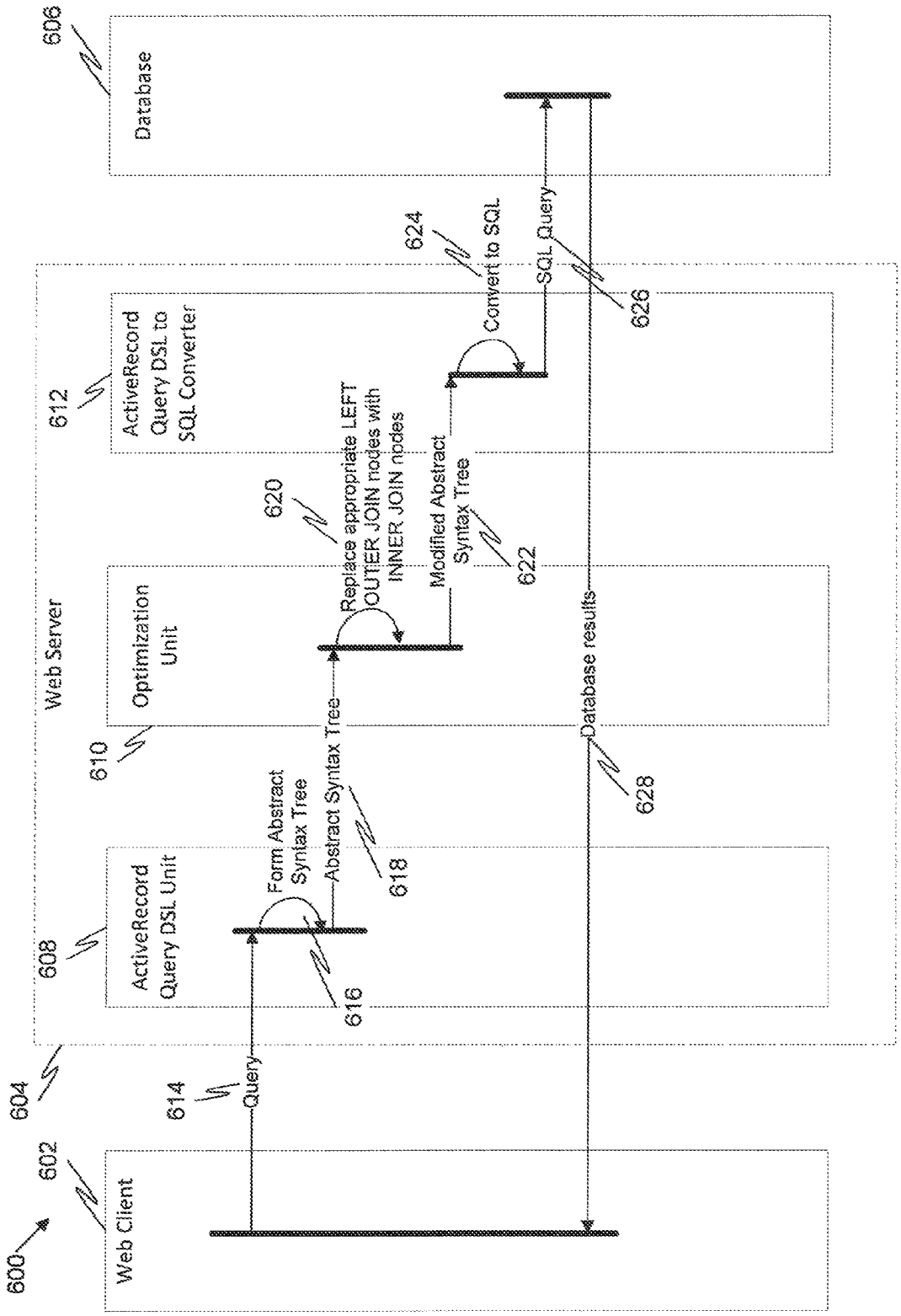
600
602
Web Client
604
Web Server
606
Database
608
ActiveRecord Query DSL Unit
610
Optimization Unit
612
ActiveRecord Query DSL to SQL Converter
614
Query
616
Form Abstract Syntax Tree
618
Abstract Syntax Tree
620
Replace appropriate LEFT OUTER JOIN nodes with INNER JOIN nodes
622
Modified Abstract Syntax Tree
624
Convert to SQL
626
SQL Query
628
Database results

FIG. 6

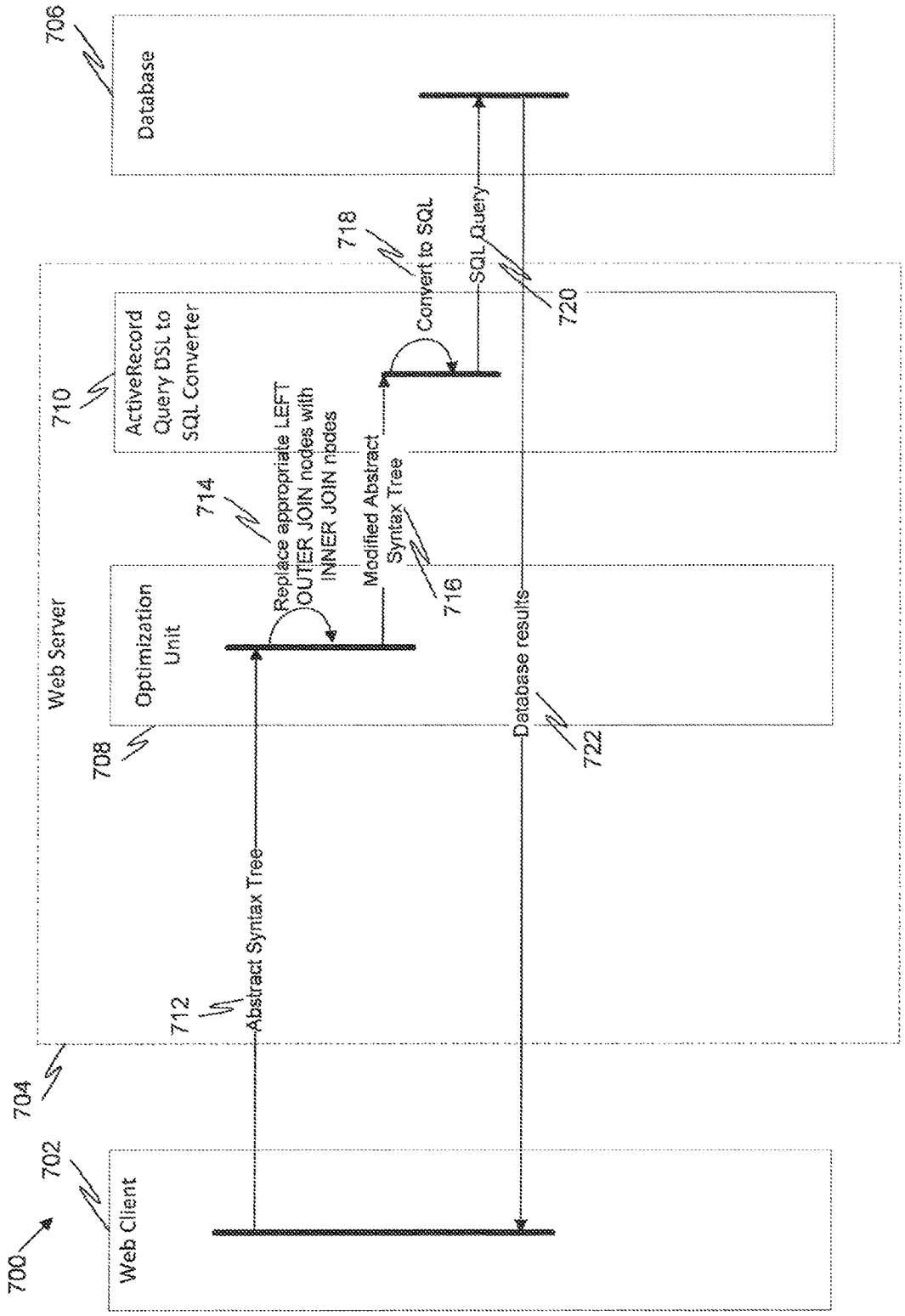
700
702
Web Client
704
Web Server
706
Database
708
Optimization Unit
710
ActiveRecord Query DSL to SQL Converter
712
Abstract Syntax Tree
714
Replace appropriate LEFT OUTER JOIN nodes with INNER JOIN nodes
716
Modified Abstract Syntax Tree
718
Convert to SQL
720
SQL Query
722
Database results

FIG. 7

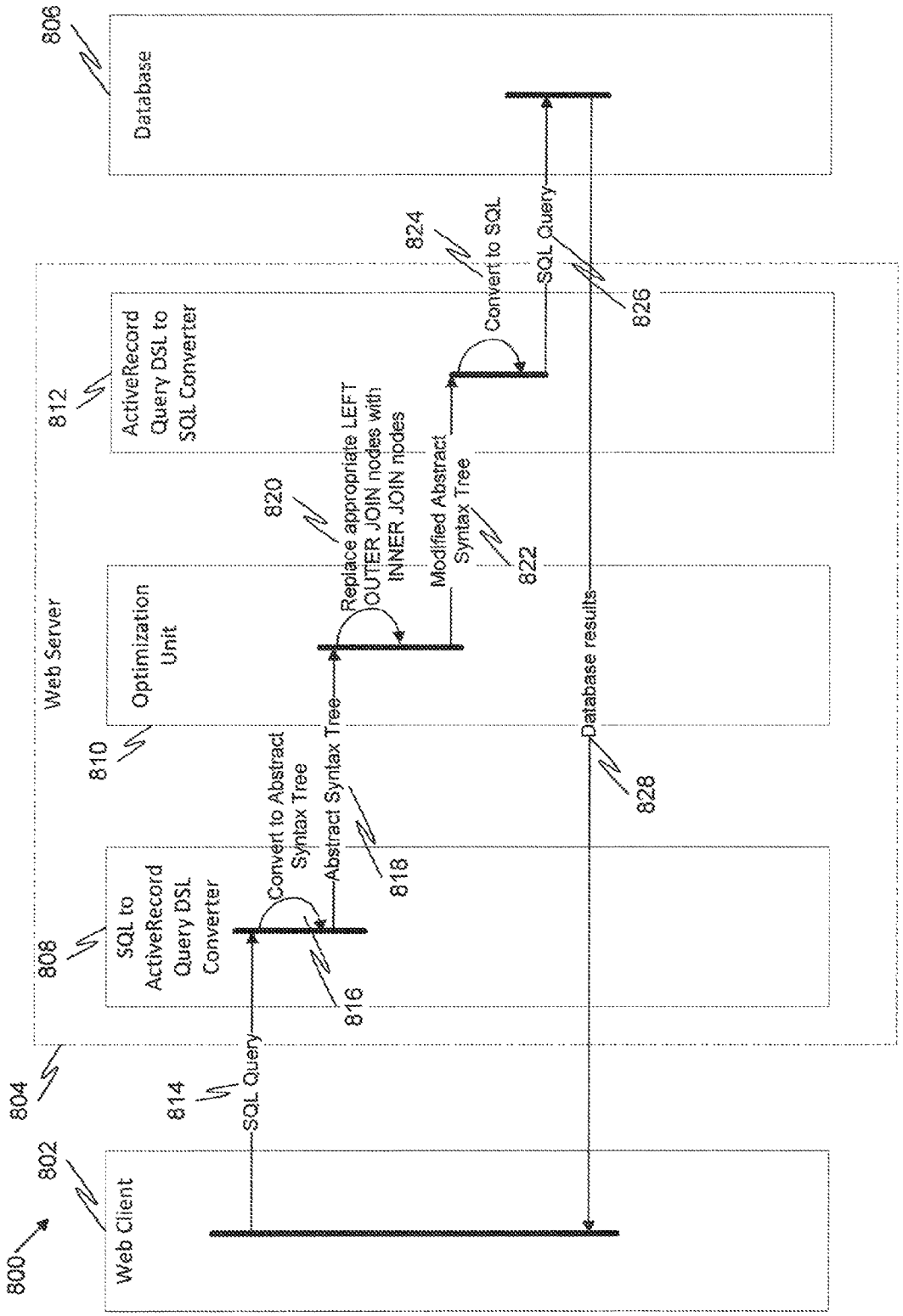
800
802
Web Client
804
Web Server
806
Database
808
SQL to ActiveRecord Query DSL Converter
810
Optimization Unit
812
ActiveRecord Query DSL to SQL Converter
814
SQL Query
816
Convert to Abstract Syntax Tree
818
Abstract Syntax Tree
820
Replace appropriate LEFT OUTER JOIN nodes with INNER JOIN nodes
822
Modified Abstract Syntax Tree
824
Convert to SQL
826
SQL Query
828
Database results

FIG. 8

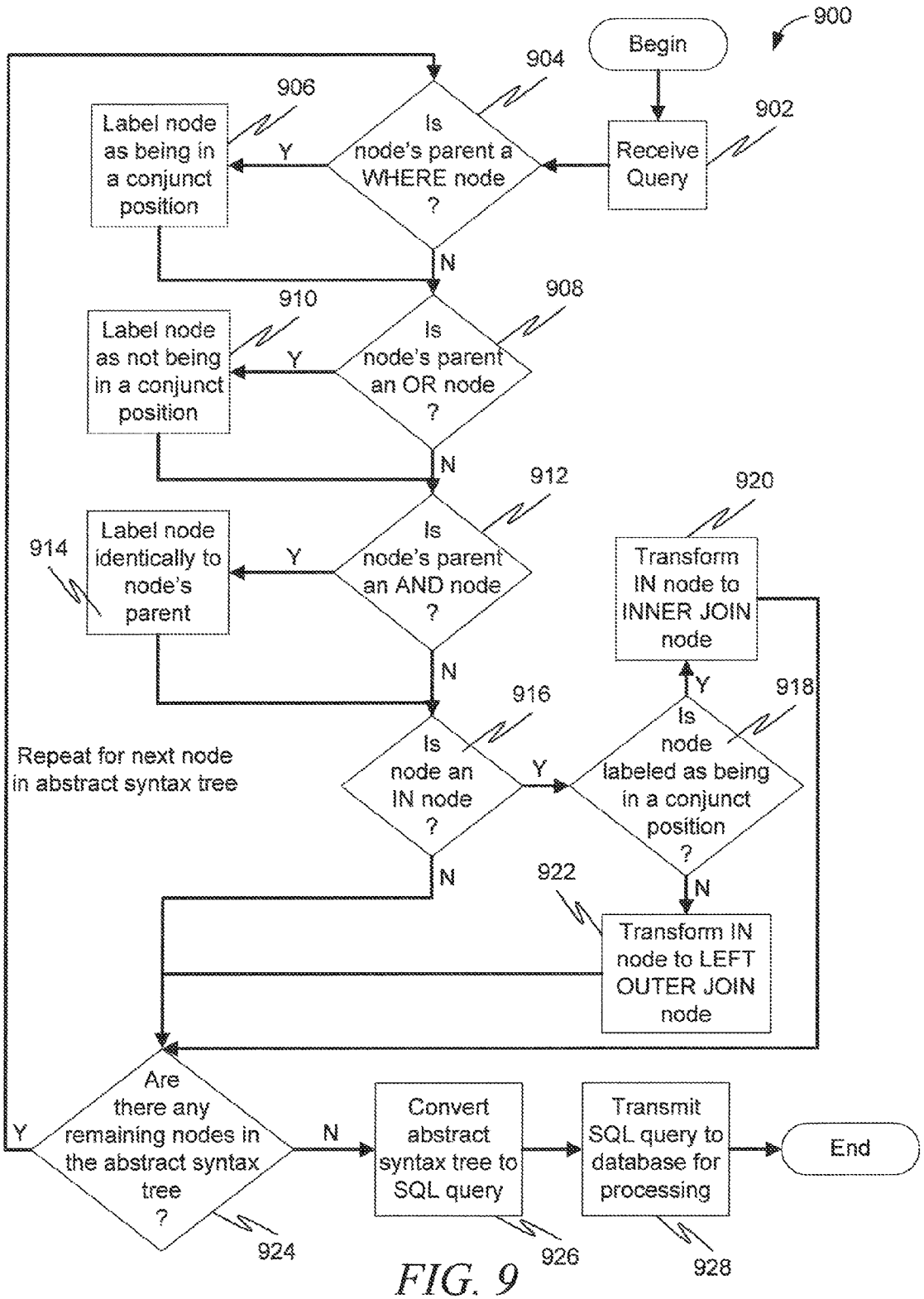
900
Begin
902
Receive Query
904
Is node's parent a WHERE node ?
Y
906
Label node as being in a conjunct position
N
908
Is node's parent an OR node ?
Y
910
Label node as not being in a conjunct position
N
912
Is node's parent an AND node ?
Y
914
Label node identically to node's parent
N
916
Is node an IN node ?
Y
Is node labeled as being in a conjunct position ?
Y
918
920
Transform IN node to INNER JOIN node
N
922
Transform IN node to LEFT OUTER JOIN node
Repeat for next node in abstract syntax tree
Are there any remaining nodes in the abstract syntax tree ?
Y
N
924
Convert abstract syntax tree to SQL query
926
Transmit SQL query to database for processing
928
End

FIG. 9

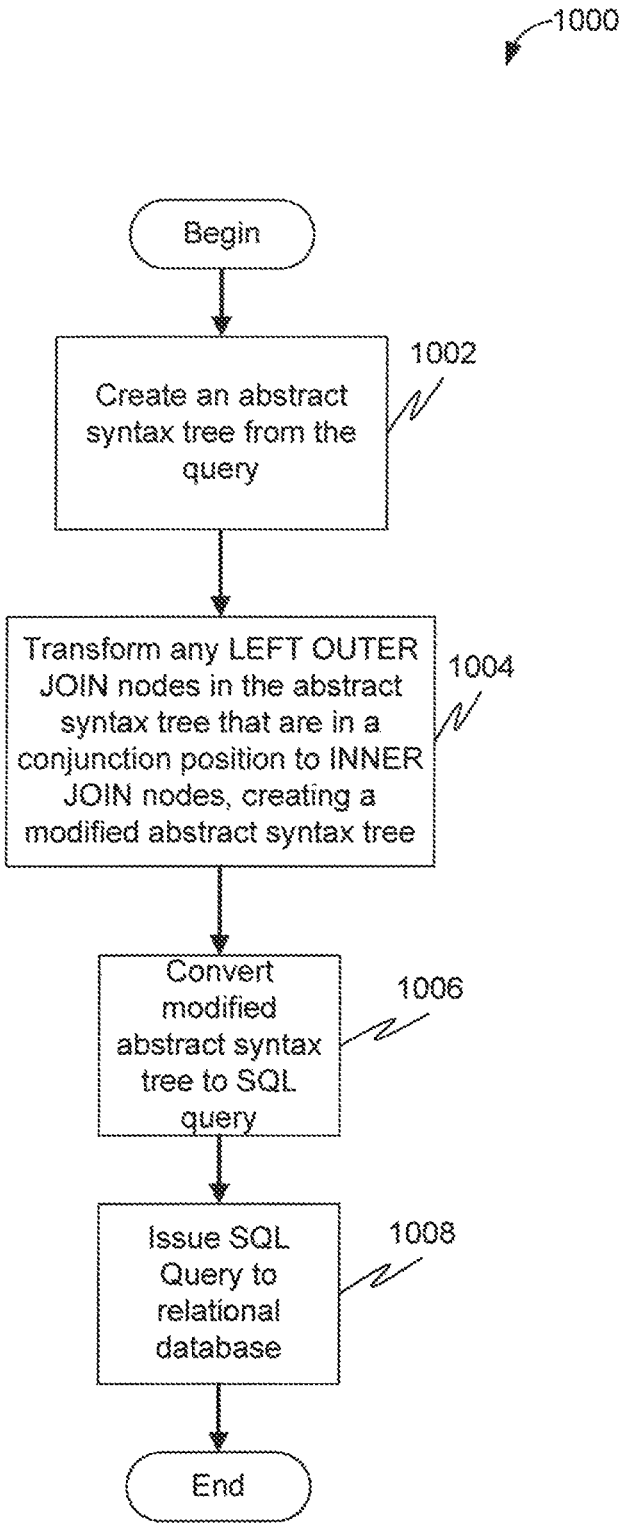
1000
Begin
Create an abstract syntax tree from the query
1002
Transform any LEFT OUTER JOIN nodes in the abstract syntax tree that are in a conjunction position to INNER JOIN nodes, creating a modified abstract syntax tree
1004
Convert modified abstract syntax tree to SQL query
1006
Issue SQL Query to relational database
1008
End

FIG. 10

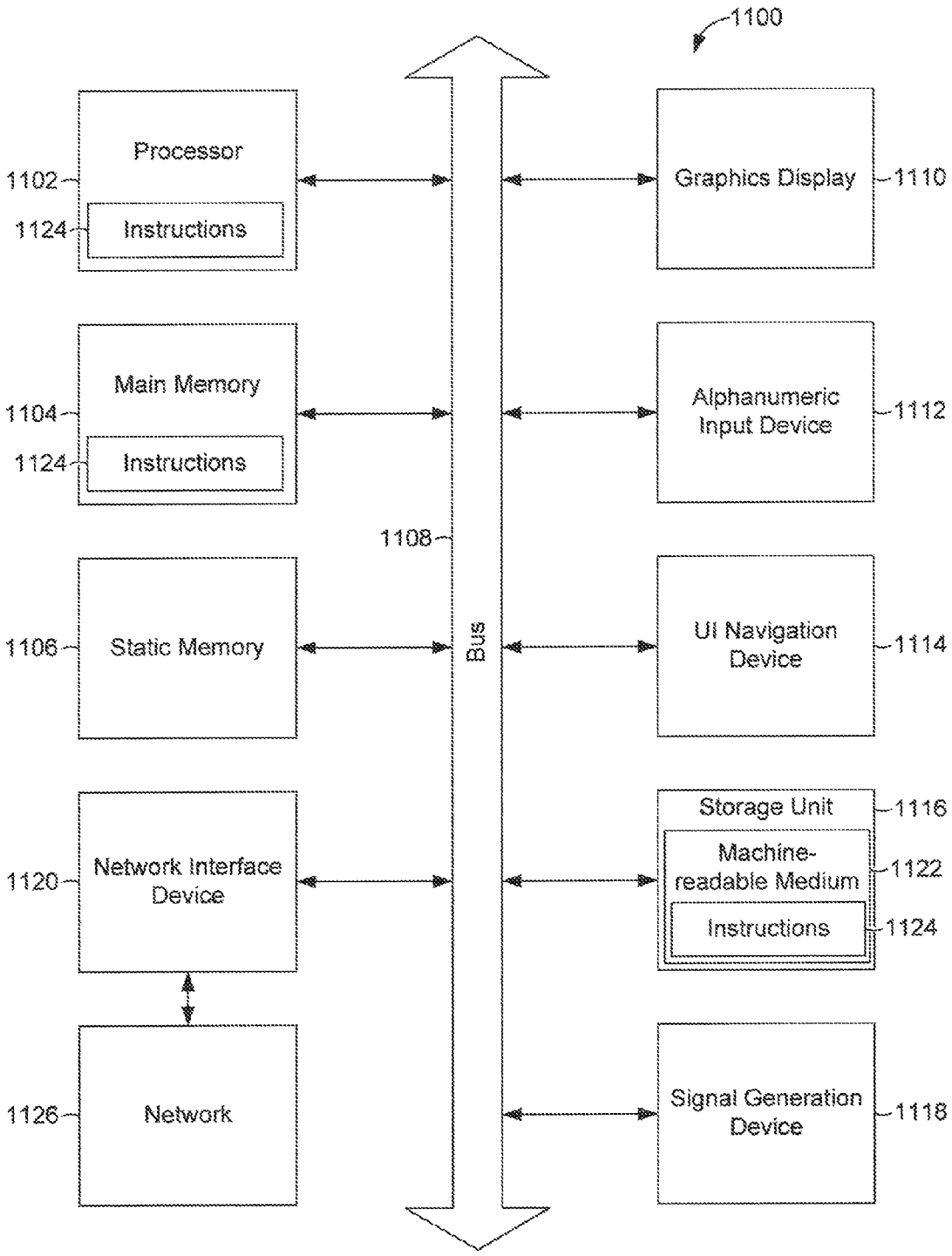
1100
Processor
1102
Instructions
1124
Main Memory
1104
Instructions
1124
Static Memory
1106
Network Interface Device
1120
Network
1126
1108
Bus
Graphics Display
1110
Alphanumeric Input Device
1112
UI Navigation Device
1114
Storage Unit
1116
Machine-readable Medium
1122
Instructions
1124
Signal Generation Device
1118

FIG. 11

METHOD AND SYSTEM FOR GENERATING OPTIMAL MEMBERSHIP-CHECK QUERIES

TECHNICAL FIELD

This document generally relates to systems and methods for use with databases. More specifically, this document relates to methods and systems for generating optimal membership-check queries.

BACKGROUND

Relational databases often receive queries in the form of Structured Query Language (SQL), or other structured format. One type of command that can be present in a SQL query is an outer join command. In an outer join command, two tables are combined without a requirement that the two tables have matching records. The resultant combined table contains all records of a first table and all records of the second table, with null in the places in the records of the second table that have no matching record in the first table. A left outer join identifies a left table as the first table and a right table as the second table, and thus the result of a left outer join contains all records of the left table even if the join condition finds no matching record in the right table. Such left outer join commands are utilized in a number of different queries, however in some cases they are inefficient to process.

An inner join is a common join operation. An inner join creates a new result table by combining column values from a first table and a second table based upon a join-predicate. A comparison is made of each row of the first table with each row of the second table to find all pairs of rows which satisfy the join-predicate. When the join-predicate is satisfied, column values for each matched pair of rows of the first table and the second table are combined into a result row.

An IN operation allows for the specification of multiple values, any one of which, if present, would satisfy the IN operation. In this manner, it is similar to providing multiple OR operations.

BRIEF DESCRIPTION OF DRAWINGS

The present disclosure is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements and in which:

FIG. **1** is a diagram illustrating a system, in accordance with an example embodiment, to perform query optimization outside of a database.

FIG. **2** is a diagram illustrating a system, in accordance with another example embodiment, to perform query optimization outside of a database.

FIG. **3** is a diagram illustrating a system, in accordance with another example embodiment, to perform query optimization outside of a database.

FIGS. **4**A-**4**E illustrate abstract syntax trees in accordance with an example embodiment.

FIGS. **5**A-**5**E illustrate abstract syntax trees in accordance with another example embodiment.

FIG. **6** is an interaction diagram illustrating a method, in accordance with an example embodiment, to perform the transformation of a query.

FIG. **7** is an interaction diagram illustrating a method, in accordance with another example embodiment, to perform the transformation of a query.

FIG. **8** is an interaction diagram illustrating a method, in accordance with another example embodiment, to perform the transformation of a query.

FIG. **9** is a flow diagram illustrating a method, in accordance with an example embodiment, of transforming a query at a web server.

FIG. **10** is a flow diagram illustrating a method, in accordance with another example embodiment, of transforming a query at a web server.

FIG. **11** is a block diagram of a computer processing system at a server system, within which a set of instructions for causing the computer to perform any one or more of the methodologies discussed herein may be executed.

DETAILED DESCRIPTION

The description that follows includes illustrative systems, methods, techniques, instruction sequences, and computing machine program products that embody illustrative embodiments. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide an understanding of various embodiments of the inventive subject matter. It will be evident, however, to those skilled in the art that embodiments of the inventive subject matter may be practiced without these specific details. In general, well-known instruction instances, protocols, structures, and techniques have not been shown in detail.

In an example embodiment, a database query is optimized by replacing certain instances of left outer join commands with inner join commands. This allows for optimization strategies to be utilized within the database upon receipt of the modified database query. One such example optimization includes inverting a loop so that a right-hand side is evaluated first and used as an outer loop for a join, which can be especially helpful if the cardinality of the right-hand side is much smaller than the cardinality of the left-hand side. This optimization can be performed prior to the query being delivered to the database for processing, allowing for an optimized query regardless of the exact type of database utilized (e.g., the solution is database-agnostic).

FIG. **1** is a diagram illustrating a system **100**, in accordance with an example embodiment, to perform query optimization outside of a database. The system **100** may include a database **102**, which may be a relational database designed to accept queries in the form of SQL commands (or other types of structured query commands). The system **100** may also include a web client **104**, such as a browser web page, which acts to communicate with a web server **106**. In some example embodiments, the web server **106** may be a light server, such as a light Java server.

In this example embodiment, the web client **104** interacts with the web server **106** to generate a query. This query may take many forms. Since the web client **104** may be designed to operate specifically with the web server **106**, the query may be formulated using a proprietary language. Indeed, it is even possible that the query not be a formalized query as one would traditionally think of it, but rather could simply be an instruction to retrieve or examine certain data, which the web server **106** could then interpret as a database query. It is also possible that the query be in the form of a database language, such as SQL. In such cases, as will be seen later, the web server **106** may additionally contain a mechanism to convert the database language to a usable form.

In the example embodiment of FIG. **1**, the web server **106** may contain a series of controller classes, including a user controller class **108**, an activity controller class **110**, and an item controller class **112**. The web server **106** may then additionally contain a series of model classes, including a user class **114**, an activity class **116**, and an item class **118**. A user at the web browser **104** directs interaction with a view of an

application presented within the browser. The browser interacts with these classes **108-118** to define a query. For example, a request for data is handled by one of the controller classes **108-112** to define a query. These classes **108-118** are used in conjunction with an ActiveRecord query domain specific language (DSL) unit **120** to convert the query from the web client **104** into an ActiveRecord query domain specific language. This may include converting the query into an abstract syntax tree (or at least refining a received abstract syntax tree to match the syntax of the ActiveRecord query domain specific language).

The abstract syntax tree is then passed to a block **122** that includes an optimization unit **124**. The optimization unit **124** acts to convert appropriate left outer join operations to inner join operations. The details of how this is accomplished are described later in this disclosure. The result of this optimization, however, is that the query has essentially been "simplified" in a way that the database **102** can perform one or more various optimizations that speed the execution of the resulting query.

The output of the optimization unit **124** may be a modified abstract syntax tree, which may be passed to an ActiveRecord Query DSL to SQL converter **126**. The ActiveRecord Query DSL to SQL converter **126** may then convert the modified abstract syntax tree to SQL, allowing it to be executed by the database **102**. The database **102** may then pass the query results to a web server interface module **128**, which can then present the results to the web client **104**. In some example embodiments the results are returned to or through other elements of system **100**, such as, through controller classes **108-112** to the web browser **104**.

Also depicted in FIG. **1** is an access control unit **130**. While the example embodiment depicted here is non-limiting in general, even within this example embodiment the access control unit **130** is optional. The access control unit **130** acts to provide access control by joining a dataset with an access control list (ACL) table. The resulting left outer join operation is one of many different types of left outer join operations that can then be optimized by the optimization unit **124**. The access control unit **130** is presented in this example embodiment as an example of how such a left outer join operation could easily be encountered, and the disclosure is not intended to be limited in applicability to left outer join operations created by an access control unit **130**. The access control unit **130** is also presented in this example embodiment because in some embodiments both the access control unit **130** and the optimization unit **124** are part of the same block **122**. This allows the access control procedures (e.g., generating left outer join operations) to be performed during the same abstract syntax tree traversal as the optimization procedures (e.g., replacing some left outer join operations with inner join operations).

FIG. **2** is a diagram illustrating a system, in accordance with another example embodiment, to perform query optimization outside of a database. This system **200** is similar to the system **100** in FIG. **1**, except that the web client **202** generates a query as an abstract syntax tree. As such, there is no need for an ActiveRecord Query DSL unit **120** to convert the query into an abstract syntax tree. The abstract syntax tree may be passed directly to an optimization unit **204** in the web server **206** (or first passed through the optional access control unit **208**). The optimized abstract syntax tree may then be passed to an abstract syntax tree to SQL converter **210**, which converts the modified abstract syntax tree to SQL, allowing it to be executed by the database **212**. The database **212** may then pass the query results to a web server interface module **214**, which can then present the results to the web client **202**.

FIG. **3** is a diagram illustrating a system, in accordance with another example embodiment, to perform query optimization outside of a database. This system **300** is also similar to the system **100** in FIG. **1**, except that the web client **302** generates a query as a SQL query. A SQL to ActiveRecord Query DSL converter **304** then acts to convert the incoming SQL query to an abstract syntax tree. The abstract syntax tree may then be passed directly to an optimization unit **306** in the web server **308** (or first passed through the optional access control unit **310**). The optimized abstract syntax tree may then be passed to an abstract syntax tree to SQL converter **312**, which converts the modified abstract syntax tree back to SQL, allowing it to be executed by the database **314**. The database **314** may then pass the query results to a web server interface module **316**, which can then present the results to the web client **302**.

As described earlier, the abstract syntax tree is optimized by replacing appropriate left outer join operations with inner join operations. It should be noted that the term "replacing" is used loosely in this disclosure so as to be broad enough to cover the concept of electing not to generate a left outer join node in the first place in favor of generating an inner join node, in instances where a left outer join node would ordinarily have been generated. In an example embodiment, an "IN" expression involving a subquery is transformed to a combination of a join expression and Boolean expression replacing the "IN" expression. The join expression is selected to be either a LEFT OUTER JOIN operation or an INNER JOIN operation based upon a conjunct position analysis, which may be performed using the abstract syntax tree, traversing from top to bottom.

By definition, a node underneath a WHERE node is evaluated as being in a conjunct position (e.g., in_conjunct_position=TRUE). In each pass, all nodes in the next level of the subtree are labeled as follows. If the node's parent is an OR node, then the node is labeled as not being in a conjunct position (e.g., in_conjunct_position=FALSE). If the node's parent is an AND node, the parent node's conjunct position status is copied to this node. If the node's parent is neither an OR nor an AND, then the node is labeled as being in neither conjunct position or not a conjunct position (e.g., the label is left blank, in_conjunct_position=NULL). Traversal may be stopped when the previous pass labels all nodes as blank.

The transformation may use an INNER JOIN if the IN node is labeled as being in a conjunct position (e.g., in_conjunct_position=TRUE). Otherwise, the transformation uses a LEFT OUTER JOIN.

FIGS. **4A-4E** illustrate abstract syntax trees in accordance with an example embodiment. In this example embodiment, the following schemas may be utilized. An EP table may include fields for id, region, and firm. An ACL table may include fields for sharer_ep_id, and recip_ep_id. Notably, the inclusion of the ACL table implies that an access control unit is utilized to generate LEFT OUTER JOINS (or at least start the process towards the generating of the LEFT OUTER JOINS, if the access control aspects are performed in the same pass as the optimization aspects).

The input statement for this example embodiment, presented in SQL form, may be:

```
SELECT *
FROM EP
WHERE (EP.firm = 'SAP AG' OR
    EP.id IN (SELECT sharer__ep__id FROM ACL WHERE
```

-continued

```
recip_ep_id = 7))
AND EP.region = 'Midwest'
```

FIG. **4**A illustrates an abstract syntax tree, in accordance with an example embodiment, formed from an input statement. The abstract syntax tree **400** includes a series of nodes **402-426**. Each node **402-426** includes a construct of the syntax, representing a "value" of a node. For example, node **420** has a "value" of "SELECT * FROM". Each node also has a field representing a flag for in_conjunct_position, depicted as **428** of node **402** but present in each node. These fields are depicted as being initially null in FIG. **4**.

FIG. **4**B illustrates the abstract syntax tree, in accordance with an example embodiment, after a first level has been labeled. Here, the AND node **408** has been labeled as being in a conjunct position because its parent node is a WHERE node **406**. It should be noted that while this figure is described as depicting the abstract syntax tree after a first level has been labeled, the process may have actually still begun with the top node **402**, stepping through each level until a level needs to be labeled.

FIG. **4**C illustrates the abstract syntax tree, in accordance with an example embodiment, after a second level has been labeled. Here, both OR node **410** and EP.region='Midwest' node **412** are labeled as being in conjunct positions because their parent node is an AND node **408**.

FIG. **4**D illustrates the abstract syntax tree, in accordance with an example embodiment, after a third level has been labeled. Here, both EP.firm='SAP AG' node **414** and IN node **416** are labeled as not being in conjunct positions because their parent node is an OR node **410**. All remaining nodes **418-426** are unlabeled because their respective parent nodes are neither OR nor AND nodes.

At this point, any IN node is transformed to a join node. The type of join node is dependent on whether the IN node is in a conjunct position or not. In this example, the IN node **416** is shown as not being in a conjunct position. As such, a plain left outer join is used (e.g., no optimization). FIG. **4**E illustrates a modified syntax tree, in accordance with an example embodiment. As can be seen, LEFT OUTER JOIN node **430** has been added, as well as an ACL.sharer_ep_id is NOT NULL node **432** and the abstract tree **400** has been rearranged.

The modified syntax tree **400** can then be converted into SQL. The resultant SQL query may represented as:

```
SELECT *
FROM EP LEFT OUTER JOIN
        (SELECT DISTINCT sharer_ep_id FROM ACL WHERE
    recip_ep_id = 7) ON EP.id = ACL.sharer_ep_id
WHERE (EP.firm ='SAP AG' OR
            ACL.sharer_ep_id IS NOT NULL) AND
            EP.region = 'Midwest'
```

FIGS. **5**A-**5**E illustrate abstract syntax trees in accordance with another example embodiment. This example embodiment is similar to the one presented in FIGS. **4**A-**4**E, except that the input statement for this example embodiment, presented in SQL form, may be:

```
SELECT *
FROM EP
WHERE (EP.firm = 'SAP AG' AND
    EP.id IN (SELECT sharer_ep_id FROM ACL WHERE
```

-continued

```
recip_ep_id = 7))
        AND EP.region = 'Midwest'
```

FIG. **5**A illustrates an abstract syntax tree, in accordance with an example embodiment, formed from an input statement. The abstract syntax tree **500** includes a series of nodes **502-526**. As with FIG. **4**, each node **502-526** includes a "value" of a node and a field representing a flag for in_conjunct_position. These fields are depicted as being initially null in FIG. **5**.

FIG. **5**B illustrates the abstract syntax tree, in accordance with an example embodiment, after a first level has been labeled. Here, the AND node **508** has been labeled as being in a conjunct position because its parent node is a WHERE node **506**.

FIG. **5**C illustrates the abstract syntax tree, in accordance with an example embodiment, after a second level has been labeled. Here, both AND node **510** and EP.region='Midwest' node **512** are labeled as being in conjunct positions because their parent node is an AND node **508**.

FIG. **5**D illustrates the abstract syntax tree, in accordance with an example embodiment, after a third level has been labeled. Here, both EP.firm='SAP AG' node **514** and IN node **516** are labeled as being in conjunct positions because their parent node is an AND node **510**. All remaining nodes **518-526** are unlabeled because their respective parent nodes are neither OR nor AND nodes.

At this point, any IN node is transformed to a join node. The type of join node is dependent on whether the IN node is in a conjunct position or not. In this example, the IN node **516** is shown as being in a conjunct position. As such, an inner join is used rather than left outer join is used (e.g., optimization occurs). FIG. **5**E illustrates a modified abstract syntax tree, in accordance with an example embodiment. As can be seen, INNER JOIN node **528** has been added, as well as an TRUE node **530** and the abstract tree **500** has been rearranged.

The modified abstract syntax tree **500** can then be converted into SQL. The resultant SQL query may represented as:

```
SELECT *
FROM EP INNER JOIN
    (SELECT DISTINCT sharer_ep_id FROM ACL WHERE
    recip_ep_id = 7)
    ON EP.id = ACL.sharer_ep_id
WHERE (EP.firm ='SAP AG' AND
    TRUE) AND
    EP.region = 'Midwest'
```

In some example embodiments, further optimization may then occur. For example, the TRUE node **530** may be eliminated from the WHERE expression as being redundant, resulting in the following SQL query:

```
SELECT *
FROM EP INNER JOIN
    (SELECT DISTINCT sharer_ep_id FROM ACL WHERE
    recip_ep_id = 7)
    ON EP.id = ACL.sharer_ep_id
WHERE EP.firm ='SAP AG' AND
    EP.region = 'Midwest'
```

FIG. **6** is an interaction diagram illustrating a method, in accordance with some example embodiments, to perform the transformation of a query. The method **600** utilizes various

components, including a web client **602**, a web server **604**, and a database **606**. The web server **604** may include an ActiveRecord Query DSL unit **608**, an optimization unit **610**, and an ActiveRecord Query DSL to SQL converter **612**.

At **614**, a query, or information to define a query, is sent from the web client **602** to the web server **604**. At **616**, the ActiveRecord Query DSL unit **608** forms an abstract syntax tree from the query. At **618**, the abstract syntax tree is forwarded to the optimization unit **610**. At **620**, appropriate LEFT OUTER JOIN nodes in the abstract syntax tree are replaced with INNER JOIN nodes, creating a modified abstract syntax tree. At **622**, the modified abstract syntax tree is sent to the ActiveRecord Query DSL to SQL converter **612**. At **624**, the modified abstract syntax tree is converted to a SQL query, which at **626** is issued to the database **606**. Database results from this SQL query are then sent to the web client **602** (perhaps through the web server **604**) at **628**.

FIG. **7** is an interaction diagram illustrating a method, in accordance with another example embodiment, to perform the transformation of a query. The method **700** utilizes various components, including a web client **702**, a web server **704**, and a database **706**. The web server **704** may include an optimization unit **708**, and an ActiveRecord Query DSL to SQL converter **710**.

At **712**, a query is sent from the web client **702** to the web server **704**. This query is in the form of, or includes, an abstract syntax tree. At **714**, appropriate LEFT OUTER JOIN nodes in the abstract syntax tree are replaced with INNER JOIN nodes, creating a modified abstract syntax tree. At **716**, the modified abstract syntax tree is sent to the ActiveRecord Query DSL to SQL converter **710**. At **718**, the modified abstract syntax tree is converted to a SQL query, which at **720** is issued to the database **706**. Database results from this SQL query are then sent to the web client **702** (perhaps through the web server **704**) at **722**.

FIG. **8** is an interaction diagram illustrating a method, in accordance with another example embodiment, to perform the transformation of a query. The method **800** utilizes various components, including a web client **802**, a web server **804**, and a database **808**. The web server **804** may include a SQL to ActiveRecord Query DSL converter **808**, an optimization unit **810**, and an ActiveRecord Query DSL to SQL converter **812**.

At **814**, a query is sent from the web client **802** to the web server **804**. This query may be in the form of a SQL query. At **816**, the SQL to ActiveRecord Query DSL converter **808** converts the SQL query into an abstract syntax tree. At **818**, the abstract syntax tree is forwarded to the optimization unit **810**. At **820**, appropriate LEFT OUTER JOIN nodes in the abstract syntax tree are replaced with INNER JOIN nodes, creating a modified abstract syntax tree. At **822**, the modified abstract syntax tree is sent to the ActiveRecord Query DSL to SQL converter **812**. At **824**, the modified abstract syntax tree is converted to a SQL query, which at **826** is issued to the database **806**. Database results from this SQL query are then sent to the web client **802** (perhaps through the web server **804**) at **828**.

FIG. **9** is a flow diagram illustrating a method **900**, in accordance with an example embodiment, of transforming a query at a web server. At **902**, a query is received. This query may either be in the form of an abstract syntax tree, or an abstract syntax tree may be generated for the query, **904-924** represent a loop repeated for each node in the abstract syntax tree, beginning with a first node in the abstract syntax tree. At **904**, it is determined if the node's parent is a WHERE node. If so, then at **906** the node is labeled as being in a conjunct position. At **908**, it is determined if the node's parent is an OR node. If so, then at **910** the node is labeled as not being in a conjunct position. At **912**, it is determined if the node's parent is an AND node. If so, then at **914** the node is labeled identically as the node's parent. At **916**, it is determined if the node is an IN node. If so, then at **918** it is determined if the node is labeled as being in a conjunct position. If so, then at **920** the IN node is transformed to an INNER JOIN node. If not, then at **922** the IN node is transformed to a LEFT OUTER JOIN node.

At **924**, it is determined if there are any remaining nodes in the abstract syntax tree. If so, then the process loops back to **904** for the next node. If not, then at **926**, the abstract syntax tree is converted into a SQL query. At **928**, the SQL query is transmitted to a database for processing.

FIG. **10** is a flow diagram illustrating a method **1000**, in accordance with another example embodiment, of transforming a query at a web server. At **1002**, an abstract syntax tree is created from the query. At **1004**, any LEFT OUTER JOIN nodes in the abstract syntax tree that are in a conjunct position are transformed to INNER JOIN nodes, creating a modified abstract syntax tree. At **1006**, the modified abstract syntax tree is converted to a SQL query. At **1008**, the SQL query is issued to a relational database.

FIG. **11** is a block diagram of a computer processing system at a server system, within which a set of instructions for causing the computer to perform any one or more of the methodologies discussed herein may be executed.

Embodiments may also, for example, be deployed by Software-as-a-Service (SaaS), Application Service Provider (ASP), or utility computing providers, in addition to being sold or licensed via traditional channels. The computer may be a server computer, a personal computer (PC), a tablet PC, a Set-Top Box (STB), a Personal Digital Assistant (PDA), cellular telephone, or any processing device capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that device. Further, while only a single computer is illustrated, the term "computer" shall also be taken to include any collection of computers that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

The example computer processing system **1100** includes processor **1102** (e.g., a Central Processing Unit (CPU), a Graphics Processing Unit (GPU) or both), main memory **1104** and static memory **1106**, which communicate with each other via bus **1108**. The processing system **1100** may further include graphics display **1110** (e.g., a plasma display, a Liquid Crystal Display (LCD) or a Cathode Ray Tube (CRT)). The processing system **1100** also includes alphanumeric input device **1112** (e.g., a keyboard), a User Interface (UI) navigation device **1114** (e.g., a mouse, touch screen, or the like), a storage unit **1116**, a signal generation device **1118** (e.g., a speaker), and a network interface device **1120**.

The storage unit **1116** includes machine-readable medium **1122** on which is stored one or more sets of data structures and instructions **1124** (e.g., software) embodying or utilized by any one or more of the methodologies or functions described herein. The instructions **1124** may also reside, completely or at least partially, within the main memory **1104** and/or within the processor **1102** during execution thereof by the processing system **1100**, with the main memory **1104** and the processor **1102** also constituting computer-readable, tangible media.

The instructions **1124** may further be transmitted or received over network **1126** via a network interface device **1120** utilizing any one of a number of well-known transfer protocols (e.g., HTTP).

While the machine-readable medium **1122** is shown in an example embodiment to be a single medium, the term "machine-readable medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions **1124**. The term "machine-readable medium" shall also be taken to include any medium that is capable of storing, encoding or carrying a set of instructions for execution by the computer and that cause the computer to perform any one or more of the methodologies of the present application, or that is capable of storing, encoding or carrying data structures utilized by or associated with such a set of instructions. The term "machine-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media.

While various implementations and exploitations are described, it will be understood that these embodiments are illustrative and that the scope of the claims is not limited to them. In general, techniques for maintaining consistency between data structures may be implemented with facilities consistent with any hardware system or hardware systems defined herein. Many variations, modifications, additions, and improvements are possible.

Plural instances may be provided for components, operations, or structures described herein as a single instance. Finally, boundaries between various components, operations, and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the scope of the claims. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements fall within the scope of the claims.

While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are illustrative, and that the scope of claims provided below is not limited to the embodiments described herein. In general, the techniques described herein may be implemented with facilities consistent with any hardware system or hardware systems defined herein. Many variations, modifications, additions, and improvements are possible.

The term "computer readable medium" is used generally to refer to media embodied as non-transitory subject matter, such as main memory, secondary memory, removable storage, hard disks, flash memory, disk drive memory, CD-ROM and other forms of persistent memory. It should be noted that program storage devices, as may be used to describe storage devices containing executable computer code for operating various methods, shall not be construed to cover transitory subject matter, such as carrier waves or signals. "Program storage devices" and "computer-readable medium" are terms used generally to refer to media such as main memory, secondary memory, removable storage disks, hard disk drives, and other tangible storage devices or components.

Plural instances may be provided for components, operations, or structures described herein as a single instance. Finally, boundaries between various components, operations, and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the scope of the claims. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements fall within the scope of the claims and their equivalents.

What is claimed is:

1. A method of transforming a query at a web server, the method comprising:

traversing, at the web server, an abstract syntax tree representing the query, for each node in the abstract syntax tree:

setting a conjunct position field in a data structure corresponding to the node as true when the node's parent is a WHERE node;

setting a conjunct position field in a data structure corresponding to the node as false when the node's parent is an OR node;

setting a conjunct position field in a data structure corresponding to the node as identical to a conjunct position field in a data structure corresponding to the node's parent node when the node's parent is an AND node;

transforming any IN node in the abstract syntax tree to an INNER JOIN node when the conjunct position field in the data structure corresponding to the IN node is set as true;

converting the abstract syntax tree into a Structured Query Language (SQL) query; and

transmitting the SQL query to a database for processing.

2. The method of claim **1**, further comprising:

receiving the query from a web client;

transforming the query into an ActiveRecord query domain specific language abstract syntax tree; and

the converting including converting an ActiveRecord query domain specific language abstract syntax tree into the SQL query.

3. The method of claim **1**, further comprising:

receiving the query at the web server as a SQL input query; and

converting the SQL input query to the abstract syntax tree.

4. The method of claim **1**, further comprising:

transforming any IN node in the abstract syntax tree to a LEFT OUTER JOIN node when the IN node is labeled as not being in a conjunct position.

5. The method of claim **1**, further comprising joining a table that is a subject of the query with an access control list table, creating an IN node in the abstract syntax tree.

6. The method of claim **5**, wherein the joining is performed during the traversing.

7. The method of claim **5**, wherein the joining is performed prior to the traversing an abstract syntax tree representing the query.

8. A web server comprising:

a processor;

memory;

a optimization unit configured to:

traverse an abstract syntax tree representing the query, for each node in the abstract syntax tree:

setting a conjunct position field in a data structure corresponding to the node as true when the node's parent is a WHERE node;

setting a conjunct position field in a data structure corresponding to the node as false when the node's parent is an OR node;

setting a conjunct position field in a data structure corresponding to the node as identical to a conjunct position field in a data structure corresponding to the node's parent node when the node's parent is an AND node; and

transform an IN node in the abstract syntax tree to an INNER JOIN node when the conjunct position field in the data structure corresponding to the IN node is set as true; and

transform an IN node in the abstract syntax tree to a LEFT OUTER JOIN node when the conjunct position field in the data structure corresponding to the IN node is set as false; and

an abstract syntax tree to SQL converter configured to convert the abstract syntax tree into a SQL query and to transmit the SQL query to a database for processing.

9. The web server of claim **8**, further comprising:

an ActiveRecord Query domain specific language unit configured to transform the query into an ActiveRecord query domain specific language abstract syntax tree.

10. The web server of claim **9**, further comprising a user controller class, a user class, an activity controller class, an activity class, an item controller class, and an item class.

11. The web server of claim **8**, further comprising:

a SQL query to abstract syntax tree converter configured to convert an SQL input query to the abstract syntax tree.

12. The web server of claim **8**, further comprising an access control unit configured to join a table that is a subject of the query with an access control list table, creating an IN node in the abstract syntax tree.

13. A non-transitory computer-readable storage medium comprising instructions that, when executed by at least one processor of a machine, cause the machine to perform operations of transforming a query at a web server, the method comprising:

Traversing an abstract syntax tree representing the query, for each node in the abstract syntax tree:

setting a conjunct position field in a data structure corresponding to the node as true when the node's parent is a WHERE node;

setting a conjunct position field in a data structure corresponding to the node as false when the node's parent is an OR node;

setting a conjunct position field in a data structure corresponding to the node as identical to a conjunct position field in a data structure corresponding to the node's parent node when the node's parent is an AND node;

transforming any IN node in the abstract syntax tree to an INNER JOIN node when the conjunct position field in the data structure corresponding to the IN node is set as true;

converting the abstract syntax tree into a Structured Query Language (SQL) query; and

transmitting the SQL query to a database for processing.

* * * * *